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REMARKS

Claims 1-20 are pending. Amendments were to correct obvious typographical errors.

NO new claims are added. Applicants are considering adding a claim 21 recites the method of claim 1 wherein the composition is substantially free of such metal-based soluble accelerators selected from ferric salts, copper salts, silver salts, and cerium salts. Moeggenborg, of course, is distinguished from this claim as Moeggenborg requires cerium salts. Such claim additions will be considered after the next office action.

Rejections over Dirksen, Moeggenborg, and Fang

Claims 1, 7-8, 18 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dirksen et al (U.S. Patent Publication No. 20020076932) in view of Moeggenborg (U.S. Patent Publication No. 20030060135) and Fang (U.S. Patent No. 6461227). Applicants respectfully traverse.

With respect to independent claim 1.: The Examiner correctly points out that Dirksen teaches polishing a substrate having a metal and a dielectric, where the metal can be ruthenium, where the polishing is done with a pad and a polishing slurry containing an abrasive of which silica is an example and an oxidizer of which periodic acid is an example. Dirksen mentions ruthenium in paragraph [0008] stating:

The substrate can comprise, consist essentially of, or consist of any suitable metal. Suitable metals include, for example, copper, aluminum, titanium, tungsten, gold, platinum, iridium, ruthenium, and combinations (e.g., alloys or mixtures) thereof. Preferably, the metal of the substrate is tungsten.

So while Dirksen notes that the substrate can contain any metal, and Dirksen lists substantially all metals known to be used in semiconductors, the disclosure of Dirksen is related to polishing tungsten. And similarly, in paragraph [0020] Dirksen says his composition can comprise any additive, and then lists by name or classification substantially every additive known to be used in CMP, including substantially every oxidizer known to be useful in CMP, and substantially every abrasive known to be useful in CMP. Therefor Dirksen mentions periodic acid as an oxidizer additive and silica as an abrasive additive. The only thing that Dirksen discloses with any specificity and requires is that the metal oxide abrasive has a total surface hydroxyl group density no greater than 3 hydroxyl groups per nm² and that the pH be below 7 (the pH is needed to inhibit hydrolyzation of the metal oxide abrasive).

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The Examiner notes Dirksen does not teach a slurry having 0.0005 to about 1 moles/kilogram of periodic acid, nor an average silica particle size of 50 nm or less, nor a removal rate of the ruthenium is at least 300 Å/min, each a limitation of claim 1. The Examiner uses Moeggenborg to provide Ruthenium removal rates of 98 and 224 nm/min, noting Moeggenborg discloses use of 0.1 to 10% abrasives, one of which is silica, and of 0.001-5% oxidizers, one of which is periodic acid. First, the Examiner's combination does not teach the invention. Like Dirksen, Moeggenborg disclose large classes of oxidizers and large classes of abrasives. The slurries used in the two examples of Moeggenborg which were then used by the Examiner to meet the ruthenium rate removal limitation of claim 1 do NOT contain periodic acid. The first slurry (98 nm/min removal rate) contains NO organic oxidizer, only cerium salts. The second slurry contains NO periodic acid as recited in claim 1, only peroxide and cerium salts. Further, NEITHER example used silica abrasive!

The combination of Dirksen and Moeggenborg is therefore not the invention claimed in claim 1, but rather the Examiner's combination results in "a method of polishing substantially any metal using a slurry of substantially any abrasive and substantially any oxidizer, including among the options polishing ruthenium, where the slurry might contains an abrasive which might include a silica abrasive (but only if it has less than 3 hydroxyl groups per nm²) and an oxidizer which might include periodic acid, the resulting combination providing a ruthenium rate over 300 angstroms per minute if the abrasive is alumina and the oxidizer is hydrogen peroxide, cerium salt, or both.

The Examiner's reason for combining Dirksen with Moeggenborg is in paragraph 13 of the Office Action:

13. At the time of the invention, it would have been prima facie obvious to one of ordinary skill in the art to modify the method of DIRKSEN to include the composition and removal rates of MOEGGENBORG because the method provides an improved polishing system for polishing noble metal containing substrate since such metals are known to be chemically stable and mechanically hard materials (MOEGGENBORG page 1 paragraphs [0006], [0007].

This standard text does not explain how the Examiner gets the combination. Yes, noble metals are hard to polish (Moeggenborg says this). But Moeggenborg is not teaching using 0.1 to 10% abrasives and of 0.001-5% oxidizers to polish ruthenium because polishing noble metals is hard. Rather, Moeggenborg teaches adding a cerium salt (a very, very strong oxidizer) to a strong

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oxidizer system. The Examiner is not trying to provide a reasoned prima facie case, but rather is combining random unrelated lines from two references.

The Examiner then uses Fang to meet the next limitation of claim 1, that the "silica abrasive having an average particle size of about 50 nm or less." Fang relates to "method for planarizing or polishing a memory or rigid disk." See Fang, abstract. As Fang notes, "The memory or rigid disk typically has a surface that comprises nickel-phosphorus, but the memory or rigid disk surface can comprise any other suitable material." Memory disks are not made of noble metals. The Examiner is asked to provide a reference that ruthenium is considered a suitable material for memory disks, and/or that the claimed abrasive is useful for ruthenium.

The Examiner's motivation for combining is provided in paragraph 14:

14. At the time of the invention, it would have been prima facie obvious to one of ordinary skill in the art to further modify the method of DIRKSEN to include the abrasive size of FANG because it provides a method planarizing or polishing with a high removal rate while minimizing defectivity (Col. 1 lines 40-45).

Fang's high rate of removal is nickel removal. The applicants ask how a disclosure of a high rate of removal of nickel in any way relates to polishing ruthenium? The stated reason for combining Fang is without any reasonable basis.

Further, what is the Examiner's expectation of success in combining random unrelated statements from three references to provide the claimed invention. If the Examiner finds the combination is nevertheless "obvious" as defined by current law, can the Examiner provide evidence that the low hydroxyl silica of Dirksen is capable of achieving the recited ruthenium polishing rate, and/or that it is feasible to prepare the low-hydroxyl silica of Dirksen having the recited particle size?

As the combined references do not teach all the limitations of the claim, and as there is no plausible reason to combine the references as combined by the Examiner, applicants request reconsideration of the rejection of claim 1 over Dirksen in view of Moeggenborg and Fang.

With respect to claim 18: Claim 1 recites that the polishing process of claim 1 is a one-step process, and also the polishing rate of ruthenium is greater than 500 angstroms per minute. Again, the Examiner relies on Moeggenborg for high ruthenium removal rates. Moeggenborg only teaches a higher ruthenium removal rate if and only is the slurry has a different abrasive than is recited in claim 1, and has a different oxidizer than is recited in claim 1, and has a

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different abrasive than is recited in claim 1, and the particle size of the abrasive is different than that recited in claim 1. Indeed, the only similarity between the examples of Moeggenborg used by the Examiner to show high ruthenium removal rate and the slurry required in claim 1 is that both slurries contain water. Applicants request reconsideration of this rejection.

Rejections over Dirksen, Moeggenborg, Fang, and Emesh

Claim 19 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dirksen in view of Moeggenborg and Fang, as applied to claims 1, 7-8, 10 and 20 above, in further view of Emesh et al. (U.S. Patent No. 5358889). Applicants respectfully traverse.

With respect to claim 19: The arguments presented against the above combination of Dirksen, Moeggenborg, and Fang in relation to claim 1 are applicable here and are incorporated by reference, as Emesh does not cure the many deficiencies of the rejection of independent claim 1.

Claim 19 recites "wherein the composition is free of sources of chloride ions." The Examiner correctly notes that Dirksen does not teach this limitation. Further, Moeggenborg teaches a cerium salt, which can but need not include chloride. The Examiner does not discuss Fang, but Fang requires a complexing agent selected from ammonia and halides. The Examiner opines that it would have been obvious to modify use the method of Dirksen with a chloride-free embodiment of Moeggenborg (which is not necessarily chloride-free, but does not mention the presence of chloride) because Emesh teaches chloride ions have a deleterious effect on Si-based integrated circuits. The Examiner is not fairly describing the art. Emesh states:

For use of RuO₂ in integrated circuits, deposition temperatures must preferably be below 700°C. to avoid thermal damage to integrated circuit elements. Also, because chloride ions may have a deleterious effect on Si based integrated circuits, a chloride free process is desirable.

Emesh does not concern itself with polishing. Emesh relates to a process of depositing and annealing a layer of ruthenium oxide on a substrate. Emesh in fact teaches chloride may be deleterious – but this is in a ruthenium metal annealing process where the circuit is heated to over 300 degrees C. Emesh does not teach or suggest that chloride is deleterious for a polishing process. Therefore, applicants request reconsideration of this rejection.

Rejections over Dirksen and Sinha

Claims 2 and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dirksen in view of Sinha (U.S. Patent Publication No. 20030119319). Applicants traverse.

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With respect to independent claim 2: Claim 2 recites a method of polishing a substrate surface ruthenium and a layer comprising a low-K dielectric material, where the polishing agents are silica abrasive, periodic acid, and a quaternary amine, at a pH of 2.5 to 5, wherein the removal selectivity of the ruthenium to the low-K dielectric is greater than 20:1.

Dirksen teaches polishing a substrate having a metal and a dielectric, where the metal can most any metal including ruthenium, where the polishing is done with a pad and a polishing slurry containing most any abrasive of which silica is an example and most any oxidizer, of which periodic acid is an example. Dirksen mentions ruthenium in paragraph [0008] stating:

The substrate can comprise, consist essentially of, or consist of any suitable metal. Suitable metals include, for example, copper, aluminum, titanium, tungsten, gold, platinum, iridium, ruthenium, and combinations (e.g., alloys or mixtures) thereof. Preferably, the metal of the substrate is tungsten.

So while Dirksen notes that the substrate can contain any metal, and Dirksen lists all metals known to be used in semiconductors, the disclosure of Dirksen is related to polishing tungsten. Similarly, Dirksen lists various things that can be polished with his slurries, which include most every item known to be polished, also including "high and low dielectric constant films." And similarly, in paragraph [0020] Dirksen states:

Such additives include surfactants (e.g., cationic surfactants, anionic surfactants, nonionic surfactants, amphoteric surfactants, fluorinated surfactants, and mixtures thereof), polymeric stabilizers or other surface active dispersing agents (e.g., phosphoric acid, organic acids, tin oxides, and phosphonate compounds), pH buffers (e.g., potassium phosphate), and polishing accelerators such as catalysts, oxidizers, and chelating or complexing agents (e.g., metal, particularly ferric, nitrates, sulfates, halides (including fluorides, chlorides, bromides, and iodides), compounds with carboxylate, hydroxyl, sulfonic, and/or phosphonic groups, di-, tri-, multi-, and poly-carboxylic acids and salts (such as tartaric acids and tartrates, malic acid and malates, malonic acid and malonates, gluconic acid and gluconates, citric acid and citrates, phthalic acid and phthalates, pyrocatechol, pyrogallol, gallic acid and gallates, tannic acid and tannates), amine-containing compounds (such as primary, secondary, tertiary, and quaternary amines and amino acids), peroxides, periodic acid and salts, perbromic acid and salts, perchloric acid and salts, perboric acid and salts, iodic acid and salts, permanganates, potassium ferricyanide, chlorates, percarbonates, persulfates, bromates, chromates, cerium compounds, and mixtures thereof).

From these broad undirected lists, the Examiner states Dirksen teaches everything in the slurry. The Examiner notes Dirksen does not teach polishing where the selectivity of ruthenium

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to a low-k dielectric is 20 or more. Indeed, Dirksen does not mention selectivity at all. The Examiner uses Sinha at paragraph [0033] to teach selectivity of ruthenium to TEOS of greater than 20. Sinha teaches:

This is important in selectively removing material from platinum-containing or other second and third row Group VIII metal-containing layers without removing, for example, significant amounts of underlying layers, such as oxide layers and nitride layers (e.g., TEOS or BPSG layers). Preferably, the selectivity for removal of material from a second and third row Group VIII metal-containing surface relative to materials containing other metals (c.g., BPSG or TEOS) is at least about 10:1, and more preferably, within a range of about 20:1 to about 100:1, depending on the chemistry and process conditions.

However, Sinha does not teach achieving this selectivity with the composition recited in claim 2. Claim 2 recites a quaternaly amine. Sinha recites on an "organic amine" which is further described in paragraph [0043]:

Examples of suitable organic amines include ethylamine (EtNH₂), methylamine (MeNH₂), triethylamine (Et₃N), and trimethylamine (Me₃N).

That is, Sinha teaches selectivity generically but provides no motivation for selecting the recited components of the slurry. And Sinha teaches selectivity but only if the slurry contains a compound not recited in claim 2.

With respect to motivation, the Examiner states:

35. At the time of the invention, it would have been prima facie obvious to one of ordinary skill in the art to modify the method of DIRKSEN to include the method of SINHA because it would provide a method for the removing of 2nd and 3rd row Group VII metal layers without removing significant amounts of underlying layers such as oxide and nitride layers (dielectric layers) (Page 4 Paragraph [0033]).

How would one of ordinary skill in the art be fairly taught the limitations of claim 2 from the unlimited disclosure of Dirksen, which relates primarily to polishing tungsten, in combination with Sinha which discloses using organic amines in polishing of noble metals? The Examiner's motivation is admirable in abstract, but Dirksen is not directed to polishing noble metals nor low k dielectrics. What is one of ordinary skill in the art to do? Start with a goal of the appropriate ruthenium to low-k selectivity recited by Sinha, and then try the millions of combinations disclosed in Dirksen (but not trying the only teaching of Sinha, that is, to use an organic amine) until a combination is obtained which reaches the desired selectivity? The Examiner's position

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on motivation is untenable, and applicants request reconsideration of this rejection of claim 2 over Dirksen in view of Sinha.

Additionally, the Examiner has not provided evidence that the low hydroxyl silica of Dirksen is capable of achieving the recited polishing selectivity to a low-k substrate. For this additional reason applicants request reconsideration of this rejection of claim 2 over Dirksen in view of Sinha.

With respect to claim 16: Claim 16 recites the method of claim 2 wherein the pH of the aqueous composition is between about 3 and about 4. Dirksen in paragraph [0018] teaches a low pH, but only to maintain the low hydroxyl content of the silica.

[0018] The metal oxide abrasive composition preferably has a pH of about 6 or less, e.g., about 5-6. More preferably, the composition has a pH of about 5 or less, e.g., about 4-5. Such a relatively lower pH will not function to reduce the total surface hydroxyl group density of the metal oxide abrasive, but rather provides for maintenance of a reduced total surface hydroxyl group density with respect to the metal oxide abrasive for a significant period of time, e.g., during storage of the metal oxide abrasive composition before use in a polishing or planarizing process.

Teaching that the abrasive should be stored at pH 4-5 does not teach that the polishing composition must have a pH of 3-4. Applicants request reconsideration of this rejection.

Rejections over Dirksen, Moeggenborg, Wang, and Ina

Claims 3, 6, and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dirksen in view of Moeggenborg and Wang (U.S. Patent No. 6316365), in further view of Ina (U.S. Patent No. 6355075). Applicants traverse.

With respect to independent claim 3: Claim 3 recites a method of polishing a substrate surface comprising ruthenium, at least one feature comprising tantalum oxide, and a dielectric material, with an aqueous composition comprising from about 0.1% to about 3% by weight periodic acid, from about 0.2% to about 6% by weight of silica abrasive having an average particle size of about 50 nm or less, wherein the composition comprises less than about 0.5% of sources of chloride ions; and wherein the polishing rate of tantalum oxide is between about 0.8 and 1.7 times the polishing rate of ruthenium.

The Examiner states in paragraph 0038 of the Office action that Dirksen teaches polishing a substrate "comprising ruthenium, a low dielectric film and a high dielectric film (tantalum oxide). In fact Dirksen states:

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[0008] The substrate comprises a metal, metal oxide, metal composite, or mixture thereof. The substrate can comprise, consist essentially of, or consist of any suitable metal. Suitable metals include, for example, copper, aluminum, titanium, tungsten, gold, platinum, iridium, ruthenium, and combinations (e.g., alloys or mixtures) thereof. Preferably, the metal of the substrate is tungsten. The substrate also can comprise, consist essentially of, or consist of any suitable metal oxide. Suitable metal oxides include, for example, alumina, silica, titania, ceria, zirconia, germania, magnesia, and combinations thereof. Preferably, the metal oxide of the substrate is silica. In addition, the substrate can comprise, consist essentially of, or consist of any suitable metal composite. Suitable metal composites include, for example, metal nitrides (e.g., titanium nitride and tungsten nitride), metal carbides (e.g., silicon carbide and tungsten carbide), and nickel-phosphorus. Substrates that consist essentially of, or consist entirely of, silicon are not suitable substrates for the method of the present invention. The present invention is particularly well-suited for the planarizing or polishing of memory or rigid disks, metals (e.g., noble metals), ILD layers, integrated circuits, semiconductors, micro-electro-mechanical systems, ferroelectrics, magnetic heads, polymeric films, and low and high dielectric constant films.

Applicants do not see Dirksen polishes "a substrate surface having at least one feature thereon comprising ruthenium and at least one feature comprising tantalum oxide, and a dielectric material." In fact, despite mentioning nearly every substrate known in integrated circuits and in memory disks, Dirksen does not mention tantalum oxide anywhere.

The Examiner notes Dirksen does not teach a layer of tantalum oxide, the amount of periodic acid recited, the amount and recited size (an average particle size of about 50 nm or less) of the silica abrasive, the chloride source, nor that the polishing rate of the tantalum oxide is between about 0.8 and 1.7 times the polishing rate of ruthenium.

The Examiner also states "(removal rate ratio of ruthenium: tantalum oxide is 0.58-1.25 calculated based on polishing rate of 300 Å/min, disclosed on page 25 of Specification)," but the significance of this is strongly contested.

The Examiner apparently uses Moeggenborg to teach the recited amount of periodic acid, somehow gleaned this amount from the paragraphs [0016] and [0017] of Moeggenborg. Moeggenborg at paragraph [0016] teaches substantially every oxidizer known in CMP, and at paragraph [0017] teaches a concentration of oxidizer encompassing substantially all known concentrations used in CMP.

The Examiner then uses Wang as stated in the Office Action at paragraph [0041]:

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41. WANG discloses a method of chemical mechanical polishing comprising a substrate with a tantalum removal ratio of the tantalum containing component in relation to the metal layer can be greater than 1 and the removal rate ratio can be less than 1 (Col. 4 lines 60-67). It further discloses that the metal can be ruthenium (Col. 4 lines 32- 36). Although WANG does not explicitly disclose applicant's polishing rate, the removal rate ratio of WANG overlaps that of applicant.

Applicants are not entirely sure why this is pertinent. Wang discloses polishing a metal and "tantalum" (metal) or a "tantalum containing component" where the polishing rate of one to another is greater than 1 or less than 1. That "teaching" is an absolute truism of polishing any dissimilar materials! The only time this "disclosure" is not met is if two dissimilar materials are polished at EXACTLY the same rate, which the undersigned has never seen. So Wang discloses the basic principle of selectivity, where selectivity is greater than 1 or is less than 1.

Claim 3 recites polishing a "feature comprising tantalum oxide." Wang is for polishing tantalum or tantalum nitride. Wang states:

The metal vias and contacts generally employ an adhesion layer (hereinafter referred to as a "barrier film"), such as a titanium (Ti), titanium nitride (TiN), tantalum (Ta), or tantalum nitride (TaN) barrier film, to adhere the metal layer to the SiO₂ substrate.

and

The term "tantalum" refers to tantalum itself, as well as tantalum-containing compounds. Thus, the tantalum can be in the form of, for example, tantalum metal or tantalum nitride.

Tantalum and tantalum nitride have properties different than tantalum oxide and of course do not polish the same as tantalum oxide. Wang does not teach polishing tantalum oxide.

The Examiner further states in paragraph [0041] that:

Although WANG does not explicitly disclose applicant's polishing rate, the removal rate ratio of WANG overlaps that of applicant. "In the case where the claimed ranges 'overlap or lie inside ranges disclosed by the prior art' a prima facie case of obviousness exists. In re Wertheim, 541 F.2d 257, 191 USPQ 90 (CCPA 1976); In re Woodruff, 919 F.2d 1575, 16 USPQ2d 1934 (Fed.Cir. 1990)." MPEP 2144.05(1)

WHAT? The claim recites a ratio of polishing rates. The Examiner does not say where in Wang he gets the rates, but just states the rates overlap our claimed range?! Surely the Examiner is not saying our claim of recited selectivity of tantalum oxide to ruthenium is obvious because in another claim we recite a ruthenium removal rate of 300 A/min and because Wang in some

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examples using persulfate as an oxidizer has a tantalum rate of a few hundred A/min, and since tantalum contains one element in tantalum oxide the claimed method is obvious. Such a rejection is totally without logic.

Applicants recite a selectivity ratio. Because in claim 1 we recite the minimum polishing rate is 300 A/min does not mean claim 3 reciting a selectivity is obvious over any other slurry which teaches polishing tantalum at 300 A/min (with no indication of the polishing rate of ruthenium, and said slurry not containing the oxidizer recited in claim 3). What is the selectivity ratio if the oxidizer is not a persulfate as in Wang but is periodic acid as recited in claim 3? Would the slurry of Wang even polish ruthenium? Or is the Examiner merely suggesting that the polishing rate of tantalum can be a several hundred A/min with some slurries, and the ruthenium rate can be a several hundred A/min using other slurries, so a claim having a recited selectivity ratio (as in claim 3) is per se obvious? Applicants are NOT CLAIMING A TANTALUM POLISHING RATE, NOR EVEN A TANTALUM OXIDE POLISHING RATE!!!

The Examiner then uses Ina to teach "a polishing composition for chemical mechanical polishing in which the substrate contains a tantalum containing compound layer that is tantalum oxide (Col. 5 lines 42-43) with a silicon dioxide abrasive which has a primary particle size of at most 20nm (Col. 5 lines 15-17,44-45) in concentrations of 1-10 wt% (Col. 5 lines 48- 50)." The Examiner is not accurately describing the reference. The text the Examiner cites, which includes column 5 lines 42-43, is as follows:

With respect to the polishing power, it is important that the polishing power is high against the copper and the tantalum-containing compound, while the polishing power is suppressed against the insulating layer. More specifically, it is necessary that polishing is accelerated against copper oxide in the upper layer of the copper layer and tantalum oxide in the upper layer of the tantalum-containing compound layer, while the stock removal rate is suppressed against the insulating layer. For this purpose, the optimum primary particle size is at most 20 nm. If the primary particle size exceeds 20 nm, polishing against the insulating layer can not adequately be suppressed.

Therefore, Ina is directed to polishing tantalum compounds (like tantalum nitride!), not tantalum oxide. Just as Ina is directed toward polishing copper, not copper oxide. The above statement is merely a realization that most likely during polishing of copper and either tantalum or a tantalum compound with a slurry having an oxidizer that copper oxide and tantalum oxide form in at least the top atom of thickness of the substrate exposed to the slurry. Ina states:

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Firstly, against the copper layer or the tantalum-containing compound layer, an oxide film will be formed by the effect of the hydrogen peroxide as an oxidizing agent. Such an oxide film is believed to be relatively brittle as compared with a usual oxide film formed by natural oxidation, due to the strong oxidizing action of hydrogen peroxide. Then, the formed oxide film will be mechanically polished by colloidal silica or fumed silica as an abrasive.

So Ina's tantalum oxide is formed from action of the hydrogen peroxide on a tantalum compound. There is no "feature comprising tantalum oxide" in Ina. And the polishing rate of Ina will depend on the tantalum containing material, not on some monolayer of oxide which is abraded away.

Further, the reason Ina uses a small diameter particle is because otherwise Ina's slurry (which does not have the same oxidizer recited in claim 3) abrades the dielectric layer too much. Can the Examiner supply a reference that this problem of excessive dielectric removal would exist with the slurry as actually recited in claim 3, as opposed to some random dissimilar slurry of Ina?

The Examiner's motivation to combine these references is also without serious logic. The Examiner states "it would have been prima facie obvious to one of ordinary skill in the art to modify the method of DIRKSEN to include the composition and removal rates of MOEGGENBORG because the method provides an improved polishing system for polishing noble metal containing substrate since such metals are known to be chemically stable and mechanically hard materials (MOEGGENBORG Page 1 Paragraphs [0006], [007])." And then "it would have been prima facie obvious to one of ordinary skill in the art to further modify the method of DIRKSEN to include the method of WANG because it provides for a manner in which the planarization efficiency, uniformity, and removal rate are maximized and undesirable effects, such as surface imperfections and damage to underlying topography are minimized (Col. 2 lines 54-60)." Never mind that Wang uses a totally different slurry and does not disclose polishing EITHER of the two compounds recited in claim 3. And the Examiner then states "it would have been prima facie obvious to one of ordinary skill in the art to further modify the method of DIRKSEN to include the polishing composition of INA because it allows the metal layer and the barrier layer to be polished at a similar and high stock removal rate (Col. 3 lines 24-27)." Again, applicants are amazed. The Examiner is not even pretending to "modify the method of Dirksen to include the polishing composition of Ina." Ina does not remotely relate to

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polishing ruthenium, it simply teaches a slurry where a tantalum containing compound and copper can be polished at near the same rate (insofar as is understood by the undersigned), and Ina does not disclose the oxidizer recited in the claim but requires a different oxidizer, and Ina does not disclose the quaternary amine recited in the claim. The Examiner is merely taking the unrelated statement about selectivity in Ina, where the selectivity of the materials in Ina is for compounds not in the claim.

Applicants request reconsideration of this rejection.

Rejections over Dirksen, Moeggenborg, and Ina

Claims 4 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dirksen in view of Moeggenborg and Ina (U.S. Patent No. 6355075).

With respect to independent claim 4: Claim 4 recites a method of polishing a substrate surface having a noble metal with an aqueous periodic acid solution having 0.0005 to about 1 moles/l kilogram of periodic acid with the pH adjusted to between about 3 and about 7 with a quaternary amine, and adding from about 0.2% to about 6% % by weight of silica abrasive having an average particle size of about 50 nm or less to the pH-adjusted aqueous composition to form a polishing slurry.

The Examiner did not describe the references as containing all the limitations of claim 4. Dirksen indeed discloses a slurry, oxidizers which can include periodic acid, a quaternary amine, abrasives which can include silica, and a pH encompassed by the claimed range of 3-7. However, nowhere do the references teach "adding from about 0.2% to about 6% % by weight of silica abrasive having an average particle size of about 50 nm or less to the pH-adjusted aqueous composition to form a polishing slurry." The order of addition here is important – the abrasive is added to the polishing compound containing the periodic acid only AFTER the amine has been added to adjust the pH. This requirement was overlooked by the Examiner.

Further, there is no suggestion that combining Dirksen's modified silica abrasive with a slurry having periodic acid and a sufficient amount of quaternary amine would result in a usable slurry.

Applicants request reconsideration of this rejection.

With respect to dependent claim 17: Claim 17 depends from claim 1, additionally requiring the aqueous composition consists essentially of water, periodic acid, one or more quaternary amines, and the silica abrasive, and wherein the solution has a pH of about 2 to about

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5. Again the Examiner did not reject claim 1 over Dirksen in view of Moeggenborg and Ina. Applicants traverse.

As discussed above, Dirksen teaches polishing substantially any substrate with substantially any oxidizer in combination with substantially any abrasive, as discussed in the various arguments above. Moeggenborg teaches a slurry to polish noble metals, but **REQUIRES** the slurry to have a rare earth salt (cerium salt), which act with the oxidizer to remove the noble metal. Moeggenborg teaches in paragraph [0008] that:

[0008] The invention provides a method of polishing a substrate comprising (i) contacting a substrate comprising at least one metal layer with a chemical-mechanical polishing system comprising an abrasive and/or polishing pad, a rare earth salt, an oxidizer that is a stronger oxidant than the rare earth salt, and a liquid carrier

Such a salt would clearly distinguish the slurry “taught” by these prior art disclosures from the slurry of claim 17, as the presence of the cerium super-oxidizer changes the basic nature of the slurry. Similarly, the only oxidizer disclosed by Ina is hydrogen peroxide, and Ina also requires an anticorrosion agent, either of which would distinguish the prior art from claim 17.

Reconsideration of the rejection of claim 17 is requested.

Rejections over Dirksen, Moeggenborg, Fang, and Sinha

Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dirksen in view of Moeggenborg and Fang as used in claim 1, in further view of Sinha (20030119319). Applicants traverse.

With respect to dependent claim 5: Claim 5 depends from claim 1. The arguments presented against this art as it relates to claim 1 are pertinent here and are incorporated here by reference, as Ina does not cure the deficiency of Dirksen in view of Moeggenborg and Fang.

Claim 5 recites the dielectric includes at least one of PETEOS dielectric, TEOS dielectric, or BSPG dielectric, and wherein the removal selectivity of the ruthenium to the dielectric is greater than about 20:1. The Examiner continues to opine that the generic disclosure of Dirksen (which relates to polishing tungsten) can be modified by combining with Moeggenborg (which uses a slurry with a rare earth salt oxidizer which is not in the claim), then further modifies the slurry by adding the small particle abrasive from Ina (which is unrelated to polishing ruthenium but used to polish nickel on memory disks), and finally further modifies this hypothetical slurry with the requirement of Sinha of selectivity (where Sinha does not teach the

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recited selectivity range, nor teaches selectivity between the recited metals). Generally, in the industry, it is known that small particles result in lower polishing rates than do larger particles, all other factors being equal. It makes no sense to modify a method by merely requiring a recited generic selectivity from Sinha (and then letting the practitioner figure out how to get there), where Sinha is the only "thing" incorporated from Sinha is a selectivity value. Sinha discloses using CeO₂ abrasive, an organic amine, and an organic acid complexing agent for polishing noble metals? Alternatively Sinha in paragraph [0040] teaches "harder particles like alumina particles with certain complexing agents such as organic acid oxidizers work more effectively than ceria or silica with respect to selective removal of the Group VIII metal-containing surface." Which components of Sinha is the Examiner saying should be incorporated into the hypothetical slurry. Does the Examiner have evidence (other than applicant's disclosure) that the resultant slurry will meet the polishing rate requirement of claim 1? One can't just modify a slurry by requiring a result of a different slurry. Even with the altered silica of Dirksen?

The rejection is substantially without logic, merely picking phrases from word searches and then cobbling them together with "motivations" that are not hinted at in the primary reference nor are pertinent to the claimed invention. Applicants request reconsideration of the rejection of claim 5.

Rejections over Dirksen, Sinha and Moeggenborg

Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dirksen as modified by Sinha, as applied to claims 2 and 16 above, in further view of Moeggenborg. Applicants traverse.

With respect to dependent claim 9: Claim 9 recites the method of claim 2, wherein the slurry has between about 0.2% to about 1% by weight of silica abrasive and from about 0.01 to about 0.05 moles periodic acid /kilogram of fluid. Claim 2 in turn requires the removal selectivity of the ruthenium to the low-K dielectric is greater than 20:1.

The Examiner at paragraph 0065 of the office action presents arguments as if claim 9 depends from claim 1, describing the particle size and ruthenium rate. My record suggests claim 9 depends from claim 2. Nevertheless, I shall treat claim 9 as depending from claim 1.

Moeggenborg indeed discloses any reasonable concentrations of oxidizer. Moeggenborg does not exactly disclose use of periodic acid, but rather states

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0016] The oxidizer is any suitable oxidizer capable of oxidizing the rare earth salt. Per-type oxidizers are particularly suitable, including inorganic or organic per-compounds. A per-compound (as defined by Hawley's Condensed Chemical Dictionary) is a compound containing at least one peroxy group ($--O--O--$) or a compound containing an element in its highest oxidation state. Examples of compounds containing at least one peroxy group include but are not limited to hydrogen peroxide and its adducts such as urea hydrogen peroxide and percarbonates, organic peroxides such as benzoyl peroxide, peracetic acid, and di-tert-butyl peroxide, monopersulfates (SO_5^{2-}), dipersulfates ($S_2O_8^{2-}$), and sodium peroxide. Examples of compounds containing an element in its highest oxidation state include but are not limited to periodic acid, periodate salts, perbromic acid, perbromate salts, perchloric acid, perchlorate salts, perboric acid, perborate salts, and permanganates. Other suitable oxidizers include bromates, chlorates, chromates, and iodates, with any appropriate counteranion, as well as iron salts (e.g., nitrates, sulfates, EDTA, and citrates), potassium ferricyanide, potassium dichromate, iodic acid, and the like.

Moeggenborg discloses the existence of periodic acid, but does not affirmatively state it is suitable. The electropotential of cerium⁺³ to cerium⁺⁴ is about 1.44 V. The electropotential of hydrogen peroxide is about 1.5 to 1.8V. I was not able to find the electro potential of periodic acid, but many oxidizers listed in the paragraph above in fact do not oxidize cerium salt. Therefore, does Moeggenborg disclose the use, or merely the existence, of periodic acid?

Claim 9 is a method claim. The Examiner treats the claim as a composition claim, merely reciting huge disclosed ranges of every compound. Moeggenborg teaches adding a very aggressive oxidizer, cerium salt, to the formulation. Such a slurry having such a super oxidizer would be expected to attack the dielectric - where is the Examiner's evidence that the polishing composition as modified by Moeggenborg does not abrade low-k dielectrics, thereby removing the slurry from the requirement in claim 2 that "the removal selectivity of the ruthenium to the low-K dielectric is greater than 20:1?" Merely citing Moeggenborg for a rate (where the rate is obtained with a different oxidizer and abrasive than those claimed), and the reciting a selectivity from a different source which uses a different oxidizer than claimed and requires a complexing agent selected from the group of a cyclic diene, an organic amine, and combinations thereof does not show the prior art teaches the invention. The Examiner is merely reverse engineering Applicant's invention by selecting unrelated statements from unrelated disclosures, while ignoring the teachings of the disclosures, with no suggestion in the art that this is the correct

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direction and no indication of a potential for success. Applicants request reconsideration of the rejection of claim 9.

Rejections over Dirksen, Moeggenborg, Fang, and further in view of Jacquinot and Buehler, and further in view of and in further view of BASIM et al (Effect of Particle Size of Chemical Mechanical Polishing Slurries for Enhanced Polishing with Minimal Defects).

Claims 11-13 are rejected under 35 U.S.C. 103(a) as being unpatentable over DIRKSEN et al (U.S. Patent Publication No. 2002/0076932) as modified by MOEGGENBORG et al (U.S. Patent Publication No. 2003/0060135) and FANG (U.S. Patent No. 6,461,227), as applied to claims 1, 7-8, 10 and 20 above, in further view of JACQUINOT et al (U.S. Patent No. 6,043,159) and BUEHLER (U.S. Patent No. 6,746,498). Applicants traverse.

With respect to claim 11: Claim 11 recites the method of claim 1, wherein at least 50% of the weight of the silica should be in a chain-like structure with a length-to-width ratio of at least 4. The Examiner gives the usual flawed reasoning of Dirksen et al as applied to claim 1. The arguments against using the combination of Dirksen, Moeggenborg, and Fang as it pertains to claim 1 are pertinent here and are incorporated by reference. Jacquinot nor Buehler, nor BASIM remedy the errors in the rejection of claim 1.

The Examiner then modifies that hypothetical slurry with the slurry of Jacquinot, saying Jacquinot's particles are chain like AGGREGATES (not chain-like structures as recited in claim 11) with a width of 50 nm and a length of 500 nm.

Does the Examiner say Jacquinot discloses aggregates, or chain-like structures? The two are not the same.

Claim 11 (unlike claim 12) does not provide for aggregates but rather requires a chain-structure, where the structure has an average particle size of 50 nm or less. If the Examiner's argument is based on 500 nm aggregates, the limitations of claim 11 are not taught.

And again, motivation to combine these references is without reasonable basis. Claim 1 recites polishing ruthenium, and requires a minimum ruthenium polishing rate. Jacquinot's particles are used to polish a silica dielectrics. Why does the Examiner think its obvious to use an abrasive designed for polishing silica in a slurry used for ruthenium? The reason provided by the Examiner is because Buehler teaches fumed silica enables high polishing rates! High rates of what?! Buehler's text is as follows:

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For the chemical mechanical polishing of metal or dielectric material, two forms of silica abrasive are commonly used--i.e., fumed silica and colloidal silica. Fumed silica may, for example, be used when polishing the dielectric material that forms the device's shallow trench isolation region. Colloidal silica may be used when polishing barrier layers, e.g., those comprising tantalum. In general, fumed silica enables a high polish rate, but exhibits poor defect performance, while using colloidal silica may limit defects, but may also reduce the polishing rate.

That is, Buehler teaches fumed silica is good for polishing a dielectric material. Which is NO REASON to modify a slurry designed for ruthenium. And the abrasive of Jacquinet that is being added? Jacquinet in the abstract states:

Process for the chemical mechanical polishing of a layer of isolating material based on silicon or a silicon derivative, in which abrasion of the layer of isolating material is carried out by rubbing said layer using a fabric which brings into play an abrasive containing an acid aqueous solution of colloidal silica containing individualized colloidal silica particles.

Jacquinet ALSO teaches using a fumed silica for polishing dielectric, and Jacquinet also is an abrasive designed for polishing a dielectric. Neither slurry (Jacquinet nor Buehler) uses an oxidizer. Neither slurry is designed for polishing a metal. So in what way would someone want to use this art to modify a slurry used in a method for polishing ruthenium with these particular abrasives? The Examiner alludes to higher rates? Just because fumed silica gives higher rates when polishing dielectric material, WHERE IS ANY SUGGESTION TO USE THE AGGREGATES OF JACQUINOT? Where is the evidence the abrasives of Jacquinet or Buehler can polish metal, much less ruthenium at the recited rates.

This rejection is very strong evidence that the Examiner is merely reverse-engineering applicant's claimed inventions with unrelated excerpts from diverse references with no thought whatever to whether the combinations of prior art make any sense. Applicants request reconsideration of this rejection.

With respect to claim 12: Claim 12 recites the method of claim 1, wherein at least 50% of the weight of the silica is in aggregates with an aggregate diameter of about 0.03 to 0.05 microns before polishing. A micron is 1000 nm, so an aggregate diameter of about 0.03 to 0.05 microns means an aggregate diameter of about 20 to 50 nm. Aggregates are defined in the specification, and are not chains, so aggregates with a diameter of between about 0.03 to 0.05 microns before polishing must be formed from particles much smaller than 30 nm. Indeed, the instant specification states in paragraph [0037]:

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[0037] The abrasive particles may form aggregates, which are particles loosely or strongly held together in clumps, where the number of particles in an aggregate depends largely on the chemistry of the composition and on the particle size. Aggregates have substantially the same dimensions, plus or minus 70%, measured in each direction, and have a plurality of particles interconnected such that a plurality of particles contact at least three other particles. Such aggregates can be desirable because they have high polishing rates as found with bigger particles but also have some resiliency, which reduces gouging. Particularly preferred for very fine features are abrasives in aggregate form with a particle size of 15 nanometers (0.015 microns) with an aggregate size of 0.03 to 0.05 microns, or abrasive with a particle size of 7 nanometers (0.007 microns) with an aggregate size of 0.02 to 0.04 microns.

The aggregates in claim 12 are therefor roughly spherical, and have an aggregate diameter of 0.03 to 0.05 microns. The 10:1 diameter to length ratio described by the examiner is not an aggregate.

The Examiner in paragraph 0077 of the Office action characterizes Jacquinet as a method of polishing "where an aqueous solution of colloidal particles of pyrogenic silica as an aggregate fumed silica (silica with 100% chain like structure as an aggregate) with an aggregate particle diameter of 5-50 nm (0.005 to 0.05 microns) (Col. 1 lines 53-56.)" This characterization is wrong. The text of Jacquinet states the primary particles are 5-50 nm, while the aggregate length (which may or may not be a diameter) is 50 and 500 nanometers:

Generally primary particles of spherical silica of 5 to 50 nanometers are obtained which form particle aggregates of a length generally comprised between 50 and 500 nanometers.

The "aggregates" of Jacquinet according to the Examiner are chains and are therefore not aggregates as defined in the specification. The Examiner on paragraph [0078] of the office action states it is obvious to combine Jacquinet with Dirksen et al "because it is important to know the optimal size distribution to enhance the removal rate without damaging the wafer," citing BASIM. Optimal for what? Can Examiner tell us what the claimed size (of either Jacquinet nor Buehler) is optimal for? Where is a small silica particle taught or suggested to be optimal for polishing ruthenium. Where are aggregates and chain like structures taught to be useful for polishing ruthenium. How many diverse methods for polishing different materials can possibly combined with no motivation? There is no motivation in the art to use this abrasive to polish a metal, nor to use the recited aggregates (which are NOT chain like structures). Applicants request reconsideration.

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With respect to claim 13: Claim 13 recites the method of claim 1, wherein the silica abrasive comprises both silica particles in a chain-like structure with a length-to-width ratio of at least 4, and also silica particles in aggregates with an aggregate diameter of about 0.3 to 0.05 microns, and wherein before polishing at least 70% of the weight of the silica is contained in the chain-like structures and the aggregates. This claim requires both chain like particles and aggregates. This is not taught in the art. Reconsideration is requested.

Rejections over Dirksen, Moeggenborg, Fang, and further in view of Athavale.

Claim 14 is rejected under 35 U.S.C. 103(a) as being unpatentable over DIRKSEN et al (U.S. Patent Publication No. 2002/0076932) as modified by MOEGGENBORG et al (U.S. Patent Publication No. 2003/0060135) and FANG (U.S. Patent No. 6,461,227), as applied to claims 1, 7-8, 10 and 20 above, in further view of ATHAVALÉ et al (U.S. Patent No. 6,261,967). Applicants traverse.

Claim 14 recites the method of claim 1, wherein the substrate further comprises a hard-mask material, and wherein the polishing rate of the hardmask material is equal to or greater than the polishing rate of the ruthenium. The Examiner states:

ATHAVALÉ discloses a substrate with a hard mask and a noble metal in which the hard mask may be used for the selective etching of the noble metal. It further discloses that the hard mask is etched selective to the noble metal and can be removed using a wet etching method (CMP) (Col 7 lines 5-11). Although ATHAVALÉ does not state that the polishing rate of the hard mask is greater than the polishing rate of the ruthenium, this aspect is inherent since the hard mask can be patterned and remain on the noble metal while the noble metal layer is patterned to its shape.

The Examiner equates wet etching with CMP with no evidence. Claim 14 REQUIRES a ruthenium polishing rate of at least 300 Å/min! Etching does not use any abrasive. How can it be the same as polishing. THE EXAMINER IS KINDLY ASKED TO PROVIDE SOME REFERENCE FOR THIS STATEMENT. The claim recites the polishing rate of the hardmask material is equal to or greater than the polishing rate of the ruthenium, and the Examiner admits the reference makes NO MENTION AT ALL OF POLISHING but merely says this is inherent since the hard mask can be patterned and remain on the noble metal while the noble metal is patterned into shape. This rejection is doubly frustrating because of the long litany of questionable rejections encountered here. SEE MPEP 2112: THE EXAMINER MUST PROVIDE RATIONALE OR EVIDENCE TENDING TO SHOW INHERENCY. "To establish

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inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.' " In re Robertson, 169 F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999) The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. In re Rijckaert, 9 F.3d 1531, 1534, 28 USPQ2d 1955, 1957 (Fed. Cir. 1993).

"In relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teachings of the applied prior art." Ex parte Levy, 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Inter. 1990). Please provide.

The Examiner then states

86. At the time of the invention, it would have been prima facie obvious to one of ordinary skill in the art to modify the method of modified DIRKSEN to include the hard mask of ATHAVALE because the hard mask allows the etching of the noble metal and is easily removed after the patterning process (Col. 1 lines 50-53)

Motivation to include a hard mask is that it is useful for earlier etching processes (which are NOT CMP!) and is easily removed? Modify the method of Dirksen to include a hard mask? I hope my frustration is clear. HOW is Examiner proposing to modify Dirksen? This is a rejection made with ZERO pertinent references. The Examiner is asked to provide invalidating references or allow the claim.

Rejections over Dirksen, in view of Sinha, in view of Ina and Wang.

Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over DIRKSEN et al (U.S. Patent Publication No. 2002/0076932) as modified by of SINHA et al. (U.S. Patent Publication No. 2003/0119319), as applied to claims 2 and 16 above, in further view of INA et al (U.S. Patent No. 6,355,075) and WANG et al (U.S. Patent No. 6,316,365). Claim 15 recites the method of claim 2, wherein the substrate further comprises at least one of tantalum oxide or titanium oxide, and wherein the polishing rate of the tantalum oxide and/or titanium oxide is between about 0.9 and 1.3 times the polishing rate of ruthenium. Claim 2 in turn recites a method of polishing a substrate surface, comprising: providing a substrate surface having at least

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one feature thereon comprising ruthenium and at least one layer comprising a low-K dielectric material, contacting the substrate with a silica abrasive and with an aqueous composition comprising periodic acid and a quaternary amine, wherein the solution has a pH of about 2.5 to about 5; and chemically mechanically polishing the substrate surface to remove a portion of the ruthenium, wherein the removal selectivity of the ruthenium to the low-K dielectric is greater than 20:1.

The Examiner first relies on Dirksen, a family of patents which relate to polishing tungsten but purportedly can polish anything and have all components known to CMP as optional ingredients in all amounts feasibly used. The Examiner notes that Dirksen did not disclose polishing tantalum oxide (or titanium oxide). The Examiner relies on Ina to show polishing tantalum oxide. Ina relates to polishing copper and a tantalum compound, and notes the tantalum is oxidized to tantalum oxide as it is polished. Whether this discloses a tantalum oxide polishing and especially a tantalum oxide polishing rate is highly questionable. The slurries of Ina do not mention the recited periodic acid oxidizer, but only discloses hydrogen peroxide, and does not mention polishing ruthenium. The Examiner relies on Wang to disclose polishing tantalum compounds (not tantalum oxide) with another metal where the selectivity is greater to or less than 1. That is, Wang discloses that the polishing rate of the tantalum compound is greater than, or is less than, the polishing rate of the metal. Further, the slurries of Wang, which do not contain the recited periodic acid oxidizer but rather polishes with a persulfate, and the Wang slurry which provide these rates are at pH 6.4 and up as opposed to the claimed pH range of 2.5 to 5. But the rate of tantalum removal brackets the 300 Å/min which is no where in the claims but which Examiner insists on using nevertheless. Finally, the Examiner must be hypothesizing that if we are held to the ruthenium rate recited in claim 1 (but not in the existing claim), then the tungsten rates of Wang bracket the 300 Å/minute removal rate for ruthenium, so if Wang used periodic acid rather than his persulfate and used pH 2.5 to 5 instead of his 6.4 plus, and if the rates of tantalum compound removal were unchanged when Wang made such hypothesized changes, and if the rate of tantalum compound (tantalum or tantalum nitride) were the same as the removal rate of tantalum oxide which Wang does not mention, then Wang makes the selectivity range obvious. The Examiner states it would be obvious to include a layer of tantalum oxide of Ina because it acts as a barrier layer, though Ina says no such thing. And it would be obvious to modify Dirksen with Wang (related to polishing copper and

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tantalum) because planarization rate, uniformity, and removal rate are maximized, though Wang does not polish the claimed substrates (either of them) and does not use the same oxidizer system.

Applicants traverse.

The claim recites a polishing selectivity. Examiner's twisty reasoning and unrelated picking of various characteristics of slurries (while ignoring the compounds which provide those characteristics of the various slurries) and Examiner's insistence that we be held to some polishing rate which is not in the claim merely show Examiner could not develop a reasonable prima facie case. Reconsideration is requested.

Except for issue fees payable under 37 C.F.R. 1.18, the Commissioner is hereby authorized by this paper to charge this fee plus any additional fees during the entire pendency of this application including fees due under 37 C.F.R. §§ 1.16 and 1.17 which may be required, including any required extension of time fees, or to credit any overpayment to Hayden Stone PLLC Deposit Account No. 50-3975.

Respectfully submitted,

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